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Optical and electrophysical properties of Ce-doped Gd3Al2Ga3O12

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Scintillators are used to detect ionizing radiation and particles of high and low energies. New challenges of modern science and technology demand new scintillation materials. Nowadays oxide crystals appear to be the most popular materials for scintillation detectors. One of such crystals is cerium-doped gadolinium-aluminum-gallium garnet ($Gd_3Al_2Ga_3O_{12}$:Ce, GAGG:Ce), it was first synthesized in 2011 [1]. GAGG:Ce is garnet type crystal with cubic group of symmetry, space group Ia3d [2].

This crystal is a non-hygroscopic, chemically stable material with high density (6.63 g/cm^3) and the highest light yield among oxygen-containing scintillators (40–60)×10^3 photon/MeV, with high radiation hardness and transparent to its own radiation [2, 3]. GAGG:Ce is considered for use in medical visualization equipment such as a sensor element in a positron emission tomograph (PET) due to the properties required for PET detectors [4].

Though physical properties of these crystals have been investigated for previous 8 years, the fundamental optical properties still have been studied slightly. For instance, refractive indices are reported in few manuscripts [5, 6] and vary considerably. Moreover the literature review showed the absence of information about $Gd_3Al_2Ga_3O_{12}$:Ce electrophysical properties.

Therefore the aim of the research is the determination of optical and electrophysical parameters of GAGG:Ce.

The investigated GAGG: Ce crystals are grown by the Czochralski method in the company JSC Fomos-Materials. In the Accredited Testing Laboratory "Single Crystals and Stock on their Base" of NUST "MISiS" the optical parameters were studied by spectrophotometric methods: transmittance and reflectance, absorbance and refractive indices. Two methods for the refractive indices determination are implemented on a spectrophotometer "Cary 5000" with the universal measuring accessory "UMA" (Agilent Technologies): the method of reflection at near-normal incidence and the Brewster method.

The spectral dependences of GAGG: Ce are non-monotonic with the characteristic absorption bands with maxima $\lambda \approx 440$ nm, $\lambda \approx 340$ nm, $\lambda \approx$ (300-310) nm, $\lambda \approx 270$ nm, $\lambda \approx 230$ nm. The estimation of the optical band gap of these crystals by the Tauc method showed a value of 5.88 ± 0.05 eV.

The electrophysical properties were investigated by the special equipment for measurement of thermal dependences of electrical conductivity.

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